ORGANIC
&/OR
NON-ORGANIC EGGS

A cointegration analysis of the Danish market for eggs

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- Exam paper –

1. INTRODUCTION

During the last decades organic products has overall become well-established on the Danish market. Interestingly enough the organic products seem to be perceived as an *alternative* to its non-organic counterpart. For the organic products are produced under certain (organic) conditions and thereby distinguishing itself from non-organic products being produced under other (non-organic) conditions; even though they still fulfils the same purpose. So it seems at least. And because an organic product generally can be used for the same purpose as its non-organic counterpart, they seem to be connected in sharing a consumptive purpose (a function or a taste) or to compensate identical preferences; i.e. they are expected to be *close substitutes*.[1] So even though organic products have become well-established on the Danish market, it would be expected to be established as an *alternative* to its non-organic counterpart.

Theoretically *close substitution* between products leads to price dependency. For instance, as the difference in the price between an organic and non-organic product gets larger, *ceteris paribus* more economic consumers will substitute the expensive for the cheaper. Thereby changes in prices for an organic product and its non-organic counterpart could be an indication of their relative dependence or independence; i.e. if the change in price for an organic product dependent on the change in price for its non-organic counterpart, this would indicate that they are close substitutes and therefore share some essential consumptive characteristics. In the case of price-dependence the common consumptive characteristic *could* be the expression of a microeconomic idea guiding the strategic decisions of the organic industry in following the price of the non-organic industry or vice versa. But in the case of independent change in prices, it *would* be consumer preferences, indicating that the organic and non-organic products are weak substitutes; i.e. that they commercially are different products or, at least, do not compensates identical preferences.

Using Danish data on the prices of eggs the focus of this essay is on whether or not organic eggs statistically are an alternative to non-organic eggs in the Danish economy. That is:

Are organic and non-organic eggs close substitutes?

[1] According to *A Dictionary of Economics* a substitute relationship arise "because the goods perform a similar function or serve a similar taste" (Bannock, G. *et al.*: 391.1975). Following Newman, P. (cap.2. 1965) this means, that the goods compensate identical preferences.

2. THEORY AND HYPOTHESIS

Classically (since Alfred Marshall) the theory of substitution has been a part of microeconomics and deeply related to the thought of equilibriums as driving forces in an economy. Discussing the application of equilibrium analysis Hardwick, P. et al. (1991) conclude, that "*a rise in a good's price will tend to put upward pressure on the price of substitutes*" (Hardwick, P. et al.: 93. 1991). Using organic eggs and non-organic eggs as an example, the thought of line is the following.

Assume that the supply of organic eggs is reduced for some reason; this is illustrated (in Fig. 1a) by the shift of the supply curve for organic eggs from SS to S´S´. At the price Op_1 this will result in an excess demand of q_3q_1 which will form an upward pressure on the price until it reach Op_2. At this price the quantity demanded is q2. So a reduction in the supply of organic eggs will *ceteris paribus* bring about a rise in its price and a reduction of the quantity demanded. If organic and non-organic eggs are *close substitutes*, the rise in the price of organic eggs will increase the demand for non-organic eggs due to consumptive identities; from DD to D´D´ (in Fig. 1b). This will put an upward pressure on the price of non-organic eggs (Op_1) until it settles at Op_2. At this price the demand for non-organic eggs has risen from Oq_1 to Oq_2. So the effect of a reduction in the supply of organic eggs is *ceteris paribus* a rise in the price of organic *as well* as of non-organic eggs; if they are close substitutes. In the case that the supply of organic eggs increases, the effect will be a reduction in the prices, and all of this holds for non-organic eggs as well because of their close substitution.

Fig. 1a

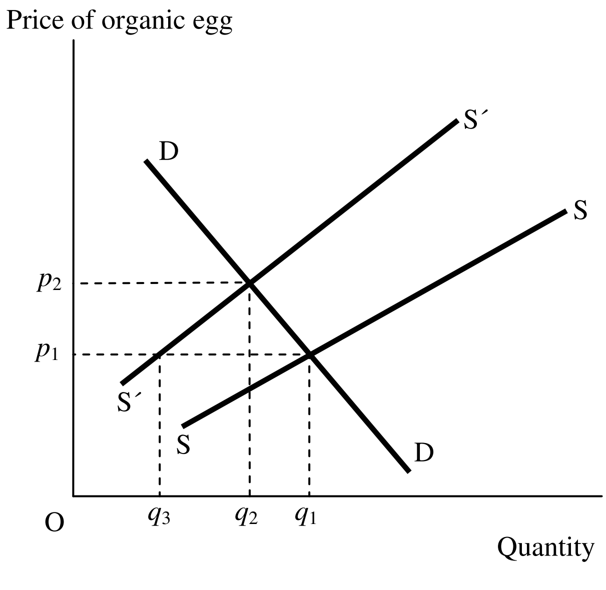
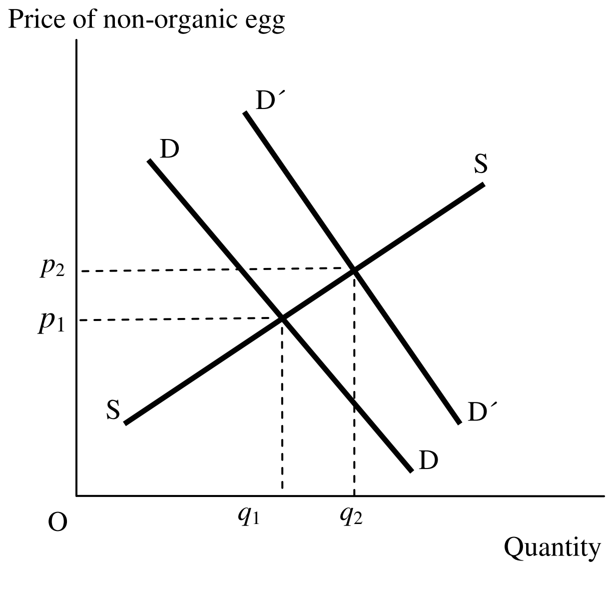


Fig. 1b



The force created by the close substitution between organic and non-organic eggs will bring about an equilibrium relation between them. Therefore:

If organic and non-organic eggs are close substitutes their prices will tend to follow each other in an equilibrium relation; i.e. a rise or reduction in the price of organic eggs will cause a rise or reduction in the price of non-organic eggs and vice versa.

This is the theoretical point, which this essay intends to follow. It will conclude from the possible equilibrium relation between the prices of organic and non-organic eggs to their possible close substitution. If the price of organic and non-organic eggs equilibrates, then they must be close substitutes (at least on an industrial strategic level); but if they do not, then they must be weak substitutes.

According to Gujarati (822. 2003) “two variables will be cointegrated if they have a long-term, or equilibrium, relationship between them”. A way to test the possibly equilibrium relation between the prices of organic and non-organic eggs, and thereby to test if these products are close substitutes, is therefore to test whether or not they cointegrate. If the prices of organic and non-organic eggs are cointegrated, they are equilibrated, and therefore organic and non-organic eggs are close substitutes. If their prices do not cointegrate, they are not, statistically, close but weak substitutes. *The hypothesis in this essay is, that prices of organic and non-organic eggs are cointegrated, and therefore that organic and non-organic eggs are close substitutes.*

3. ASSUMPTIONS, DATA & EMPERICAL MODELS

Before getting any deeper with the data, some points about the assumptions involved in testing this hypothesis need to be expressed. Because the data used are time series data, the assumptions are different from those underlying cross sectional data. Instead of assuming that the error terms are identical and independently distributed, the assumption concerning time series data is, that they are (weakly) stationary; meaning that they have a constant mean and variance over time, and that there covariance only depends on the time distance (Gujarati: 797. 2003). If this assumption is fulfilled, the law of large numbers and central limit theorem makes the OLS estimator consistent and asymptotically normally distributed. If this is not the

case, the estimates are invalid and can not be trusted. One exception is the case of cointegration, where two nonstationary time series share a common trend.

Fig.2

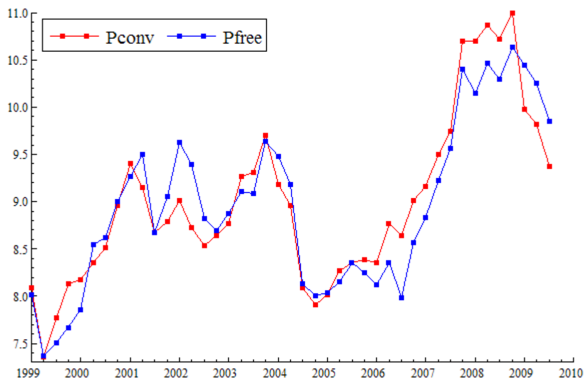


Table 1 - Correlation

	P_{conv}	P_{free}	$P_{n\text{-}org}$	P_{org}
P_{conv}	1.00	-	-	-
P_{free}	0.93	1.00	-	-
$P_{n\text{-}org}$	0.98	0.98	1.00	-
P_{org}	0.90	0.81	0.87	1.00

Table 2 – Descriptive statistics

	Mean	Std.Devn.	Skewness	Excess Kurtosis	Minimum	Maximum	Normality[2] - $Chi^2(2)$
P_{conv}	8.996	0.867	0.683	-0.075	7.357	10.994	5.0489 [0.0801]
P_{free}	8.954	0.868	0.230	-0.862	7.370	10.640	2.0785 [0.3537]
$P_{n\text{-}org}$	8.975	0.853	0.442	-0.509	7.364	10.817	2.7164 [0.2571]
P_{org}	15.653	1.059	1.179	0.328	14.270	18.450	26.508 [0.0000]**

The data used to test the hypothesis is Danish quarterly prices on eggs (measured as Danish kroner per kilo eggs) from *Danmarks Statistik*.[3] These data include the prices on organic eggs (P_{org}), conventional eggs (P_{conv}) and free range eggs (P_{free}) in the period 1999:1 to 2009:3. As a visual inspection of the prices of conventional and free range eggs shows (in figure 2), their prices are quiet similar. Though they periodically diverge, they seem to follow one another closely. Table 2 shows that their means, standard deviations, minimums and maximums are almost identical, while their skewness and excess kurtosis shows some difference. The especially larger skewness in the prices of conventional eggs seems to make it look non-normally distributed.

One could test the equilibrium relation or cointegration between the prices of organic eggs and the prices of conventional and free range eggs, but that will not be case here. To keep things simple the mean of the prices of conventional and free range eggs are used as the variable for non-organic eggs ($P_{n\text{-}org}$). Thereby an exclusive alternative between organic and non-

[2] The PcGive test for normality is based on the test proposed by Doornik and Hansen, who employ a small sample correction on the JB-test; it test the joint hypothesis that skewness and excess kurtosis equals zero.
[3] *Månedsstatistik om landbrugsforhold: Æg*. www.statistikbanken.dk.

organic eggs is secured; i.e. in this essay the consumer faces the binary alternative: Either to buy organic or non-organic eggs.

As table 1 show, though the correlation between P_{org} and $P_{n\text{-}org}$ is lower than between P_{org} and P_{conv}, it is higher than the correlation between the P_{org} and P_{free}. That is the compromise of averaging the prices of conventional and free range eggs, but it overall enhances the correlation with the price of organic egg. The mean, standard deviation, minimum and maximum of the $P_{n\text{-}org}$ corresponds to the ones of P_{conv} and P_{free}, while the sign of non-normality seems to have been averaged out. The mean, standard deviation, minimum and maximum of the P_{org} all have a higher level and, due to especially a large skewness, the normality is significantly rejected.

Fig. 3a

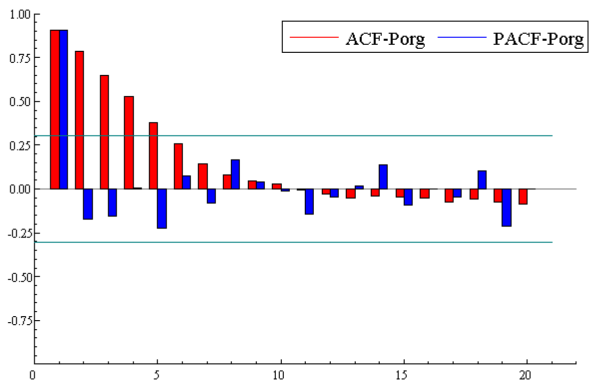


Fig. 3b

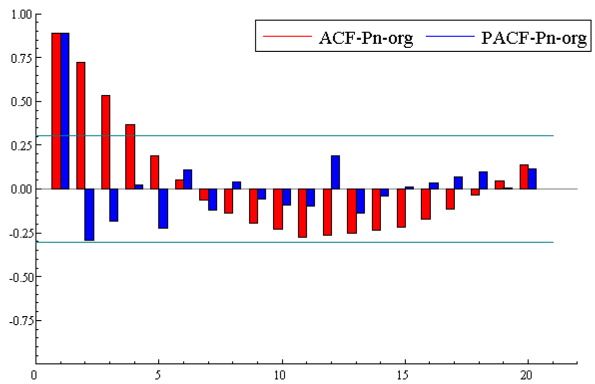


Figure 3a and 3b shows the autocorrelation function (ACF) and the partial autocorrelation function (PACF) of respectively P_{org} and $P_{n\text{-}org}$. They show significantly signs of autocorrelations in both time series, and following Verbeck (284. 2004) an ACF that tails off and a PACF that is close to zero after the first lag, indicates that both time series are AR(1) processes; all though $P_{n\text{-}org}$ could be an AR(2) due to the near significant PACF at lag 2.

Fig. 4

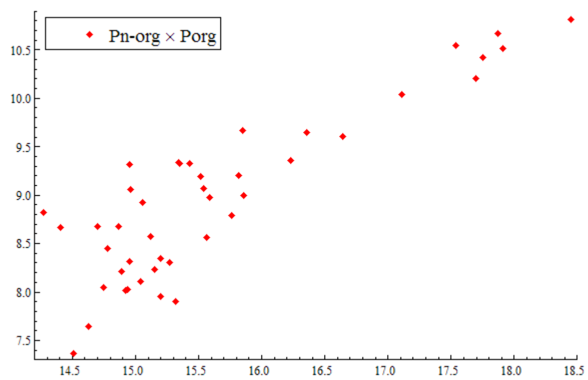
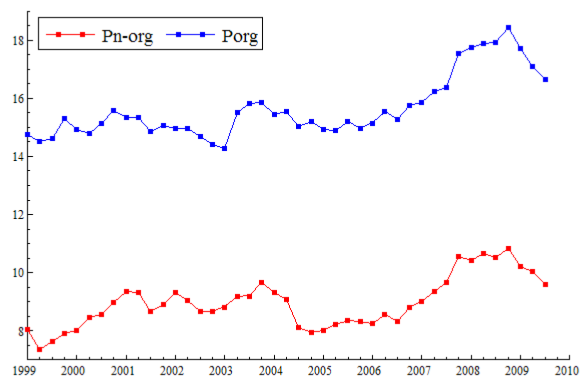


Fig. 5



In figure 4 the two time series are plotted against each other showing a positive relation. To get an initial intuition about their relation and its expected non-stationarity and to perform a Cointegrating Regression Durbin-Watson (CRDW) test, the prices of organic eggs ($P_{org.t}$) is regressed on the prices of non-organic eggs ($P_{n\text{-}org.t}$) using OLS as estimator:

$$P_{org.t} = \beta_0 + \beta_1 P_{n\text{-}org.t} + u_t \qquad \textbf{(1)}$$

In model (1) β_0 is the intercept, β_1 the slope and u_t the error term, which is assumed to be a serially uncorrelated innovation with zero mean and constant variance (i.e. a stationary process). The result of model (1) is expected to show a positive significant β_1 due to the positive relationship in figure 4 and signs of positive autocorrelation due to the character of the persistence shown in figure 5 (a rise in the price seem to be followed by another rise, and a fall by another fall), indicating that the prices of organic and non-organic eggs are non-stationary. The null hypothesis of the CRDW test is the presence of a unit root in u_t, or no cointegration relationship between the prices of organic and non-organic eggs, and though it depends on the process that generated the data, it can be used as a suggestion for, whether or not a cointegration relationship is present (Verbeck, M: 316. 2004).

Fig. 6

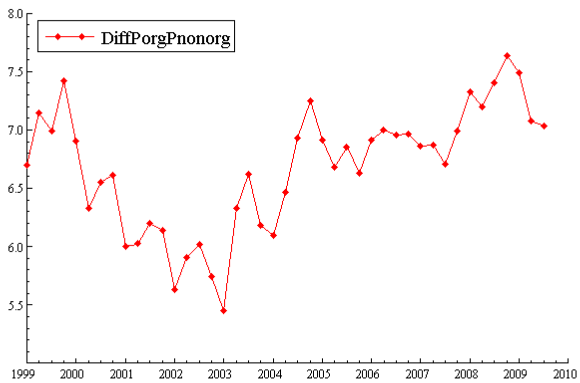
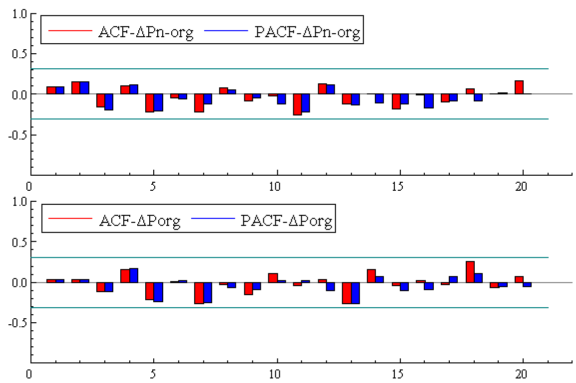


Fig. 7



In figure 5 the prices of organic and non-organic eggs might seem to follow each other from time to time, which is a sign of cointegration. But plotting the difference between these shows (in figure 6), that their relationship is not constant over time indicating, that they are not cointegrated; especially the period 2000-2004 deviates with a lower price-difference. Figure 7 show the ACF and PACF of the first differences of each prices and it seems quiet stationary. This indicates that both prices are integrated in order one I(1), which support the presence of a unit root process. But taking figure 6 into account the prices of organic and non-organic eggs may actually be spuriously related; that is their unit root processes do not cointegrate or the

residuals from their relation are not stationary (Verbeck, M: 314. 2004). If this is statistically validated, the hypothesis, that organic and non-organic eggs are close substitutes, is rejected.

Cointegration means that long-run components dominating each time series cancel each other out, establishing a mean reverting relation and makes these otherwise non-stationary series stationary (I(0)); i.e. makes the mean and variance of their relationship constant and their autocorrelation only dependent on time distance (Verbeck, M: 315. 2004). Such long-run components are characterized by the unit root processes indicated in figure 7. Therefore the prices of organic and non-organic eggs are tested for the present of a unit-root using the Augmented Dickey-Fuller test on a model with 3 lags to take account of seasonality (i.e. an AR(3)-model)[4]; once again using the OLS estimator:

$$\Delta P_{org.t} = \beta_0 + \pi P_{org.t-1} + \beta_1 \Delta P_{org.t-1} + \beta_2 \Delta P_{org.t-2} + \beta_3 \Delta P_{org.t-3} + u_t \qquad \textbf{(2)}$$

$$\Delta P_{n\text{-}org.t} = \beta_0 + \pi P_{n\text{-}org.t-1} + \beta_1 \Delta P_{n\text{-}org.t-1} + \beta_2 \Delta P_{n\text{-}org.t-2} + \beta_3 \Delta P_{n\text{-}org.t-3} + u_t \qquad \textbf{(3)}$$

In model (2) and (3) $\Delta P_{org.t}$ is the first difference of the price of organic eggs and $\Delta P_{n\text{-}org.t}$ the first difference of the price of non-organic eggs. Once again u_t is the error term and assumed to be a stationary process. Going from general to specific deleting insignificant lags to get a well specified model, the null hypothesis of Augmented Dickey-Fuller test is $\pi = 0$ or the presence of a unit-root process. Because the prices of eggs under the null are a unit-root process and therefore non-stationary, the t-statistics follows the Dickey-Fuller distribution; all other coefficients follow the standard t-distribution.

As figure 5 shows the prices overall seems to wander around a non-zero mean, rather than following a deterministic trend, and therefore model (2) and (3) includes an intercept accumulating a stochastic trend in the presence of a unit root, but does not include a trend; also there seems no immediately theoretically explanation for including such a trend. It is expected, that the null hypothesis cannot be rejected in either models, concluding that the prices of organic and non-organic eggs both have a unit root.

If the tests of unit roots cannot be rejected, the prices of organic and non-organic eggs are tested for possible cointegration. Using the augmented Dickey-Fuller test, the residuals from model (1) are tested for the presence of a unit root, following the argument that if the prices of

[4] Larger models was estimated, but they did not lead to any alternative conclusions. This has been the case for all the models used in this essay.

organic and non-organic eggs are not cointegrated, then any linear combination, and therefore also the residuals, will be nonstationary. (Gujarati, D. M.: 823. 2003). Again the estimator is OLS, and 3 lags are included to get a well specified model:

$$\Delta\hat{e}_t = \pi\hat{e}_{t-1} + \beta_1\Delta\hat{e}_{t-1} + \beta_2\Delta\hat{e}_{t-2} + \beta_3\Delta\hat{e}_{t-3} + u_t \qquad \textbf{(4)}$$

In model (4) $\hat{e}_t$ is the residuals from model (1), Δ indicates their first differences and u_t is once again stationary error terms. π is the coefficient used in testing for a unit root process or in this case for cointegration of the prices of organic and non-organic eggs. Because the OLS estimator minimizes the sample variance in model (1), it makes the residuals look as stationary as possible (Verbeck, M: 316. 2004). Therefore the appropriate critical values for π are even more negative than those from the standard Dickey-Fuller test; all other coefficients follow the standard t-distribution. The null hypothesis in model (4) is the presence of a unit root in the residuals or that the prices of eggs are *not* cointegrated; i.e. that their relation is spurious. Model (4) does not include an intercept, because the residuals are assumed to have a zero mean. Following the overall hypothesis of the essay, it is expected, that the null hypothesis is rejected.

As emphasized by Gujarati (825. 2003) if two variables are cointegrated, then their relationship can be expressed in an error correction mechanism, which leads to estimating an error correction model. If cointegration is not accepted in the residual-based test in model (4), this does not mean that cointegration between the prices of organic and non-organic eggs is rejected, but merely that it is not possible to reject, that these prices are not cointegrated or that they are spuriously related.

According to Verbeck (319. 2004) if two variables both are I(1) and can be represented in an error-correction model, then they are cointegrated. Therefore even if, due to the results from the residual-based test in model (4), it cannot be rejected, that the prices of organic and non-organic eggs are *not* cointegrated, it would still make sense estimating an error correction model. And because the OLS estimator is super consistent in estimating cointegrating time series (i.e. it converges to the true value at a faster rate than the conventional asymptotics) the normal t-values can be used in evaluating the error correction model (Verbeck (314, 318. 2004). But that is *if* the time series cointegrate.

So if the hypothesis of no-cointegration cannot be rejected in model (4), then *assuming* cointegration and estimating an error correction model could establish an indication of the reasonability of holding such an assumption; that is, if the residual-based test in model (4) cannot reject, that the prices of organic and non-organic eggs do not cointegrate, and they do not error correct in the error correction model, then there would be no reason to maintain the hypothesis, that organic and non-organic eggs are close substitutes. If the prices do error correct, but no-cointegration cannot be rejected, then this essay cannot come up with a clear cut answer concerning its hypothesis.

Therefore regardless of the result of the residual-based test for cointegration in model (4), error correction models for $P_{org.t}$ and $P_{n\text{-}org.t}$ are estimated, including 3 lags as usual to get a well specified model, and using the OLS estimator:

$$\Delta P_{org.t} = \beta_0 + \pi\hat{e}_{t-1} + \beta_1\Delta P_{org.t-1} + \beta_2\Delta P_{org.t-2} + \beta_3\Delta P_{org.t-3} + \beta_4\Delta P_{n\text{-}org.t} + \beta_5\Delta P_{n\text{-}org.t-1} + \beta_6\Delta P_{n\text{-}org.t-2} + \beta_7\Delta P_{n\text{-}org.t-3} + u_t \quad \textbf{(5)}$$

$$\Delta P_{n\text{-}org.t} = \beta_0 + \pi\hat{e}_{t-1} + \beta_1\Delta P_{n\text{-}org.t-1} + \beta_2\Delta P_{n\text{-}org.t-2} + \beta_3\Delta P_{n\text{-}org.t-3} + \beta_4\Delta P_{org.t} + \beta_5\Delta P_{org.t-1} + \beta_6\Delta P_{org.t-2} + \beta_7\Delta P_{org.t-3} + u_t \quad \textbf{(6)}$$

In model (5) and (6) Δ indicate first differences, β_0 is a constant and u_t stationary error terms as usual. Assuming cointegration between the prices of organic and non-organic eggs, which is expected, a significant π, following the standard t-distribution, expresses the average speed of adjustment from one quarter to the next of respectively the prices of organic eggs in model (5) and non-organic eggs in model (6). Or in other words a significant π expresses how large a part of a given disequilibrium, in the relationship between the prices of organic and non-organic eggs, on average is adjusted or corrected in one quarter. The results of model (5) and (6) are expected to show, that while the price of organic eggs does error correct, the price of non-organic eggs does *not*, i.e. a significant π in model (5), but not in model (6). This result is expected, because the share of the Danish market for eggs is expected to be considerable larger for non-organic than organic eggs, making organic eggs an industrially price-follower.

4. RESULTS

In this section the results from estimating the models are discussed in relation to the overall purpose; namely to test whether or not organic and non-organic eggs are close substitutes. All results stems from the program Oxmetrics 5.00, and the output is collected in the appendix.

Model (1)

The estimates of model (1) are[5]:

$$\hat{P}_{org.t} = \underset{(6.93)}{5.93} + \underset{(11.4)}{1.08}P_{n\text{-}org.t} \qquad \textbf{(1)}$$

$$R^2 = 0.76 \qquad DW = 0.40$$

and the results from its misspecifications tests are:

LM-test	F(3,38) = 27.758 [0.00]
ARCH-test	F(3,35) = 3.404 [0.03]
Normal. test	$Chi^2(2)$ = 5.106 [0.08]
Hetero test	F(2,38) = 0.192 [0.83]
RESET test[6]	F(1,40) = 0.160 [0.00]

The coefficient of $P_{n\text{-}org.t}$ is about 1 and highly significant, which meets the expected positive relation between the prices, showing that a change in the price of non-organic eggs is followed by an almost identical change in the price of organic eggs in the same time period; indicating a strong relationship between the prices of organic and non-organic eggs. But the Durbin-Watson statistic (DW) at 0.40 is below the d_L statistic for 1 explanatory variable and 40 observations, which is 1.442; meaning that the null hypothesis of no positive autocorrelation cannot be rejected. Furthermore the LM-test results in a statistic of 27.758 with F(3,38), so the null hypothesis of no autocorrelation is rejected. Both tests therefore support the expected positive autocorrelation, which invalidates the interpretation of the coefficients do to the presence of non-stationarity.

The R^2 is quiet high, but following Gujarati (807. 2003) a R^2>DW is a rule of thumb on suspecting a spurious regression, and this is actually the case in model (1); i.e. 0.76>0.40. Following Hendry, D. et al. (18. 2000) if model (1) indeed is a spurious regression, then the proper critical values for a sample size of 100 is 14.8 on a 5% level. The t-value at 11.4 is

[5] The t-values are in parentheses.
[6] The RESET test tests the null of correct specification of the original model against alternative functional forms.

indeed smaller than this, and therefore the null hypothesis (that the coefficient of $P_{n\text{-}org.t}$ equals zero) cannot be rejected, if model (1) is a spurious regression. So if this is the case, then prices of organic and non-organic eggs are not cointegrated. Also the critical values for the Cointegrating Regression Durbin-Watson test with 50 observations and two variables on a 5% level is 0.72 (Verbeck, M: 317. 2004), which is larger than the DW of 0.40 from model (1), whereby the null hypothesis of cointegration is rejected.

Model (1) is therefore clearly misspecified and nonstationary indicating a possible spurious relationship between the prices of organic and non-organic eggs.

Model (2) – (3)

Next the two time series was tested for the presence of one unit root process. Deleting insignificant lags of the first differences, and thereby ending in the initially suspected AR(1) model, the estimates of model (2) and the results from its misspecifications tests are:

$$\Delta\hat{P}_{org.t} = \underset{(1.29)}{1.243} - \underset{(-1.25)}{0.077}P_{org.t-1} \qquad \textbf{(2)}$$

LM-test	$F(3,37) = 0.222$ [0.88]
ARCH-test	$F(3,34) = 0.382$ [0.77]
Normal. test	$Chi^2(2) = 6.070$ [0.05]
Hetero test	$F(2,37) = 0.476$ [0.63]
RESET test	$F(1,39) = 0.160$ [0.69]

As the misspecification tests show, only the null hypothesis of normally distributed residuals is rejected on exactly the 5% level, so the model is overall accepted as well specified. The coefficient used in testing for a unit-root process ($P_{org.t-1}$) is almost zero (-0.077) and its t-value is -1.25. The critical value for the Dickey-Fuller test with a sample size of 50 observations and a constant is -2.89 on the 5% level (Verbeck, M: 269. 2004), which is smaller than the observed -1.25. Therefore the null hypothesis of the presence of a unit root process in the prices of organic eggs cannot be rejected as expected.

In the case of non-organic eggs, after deleting insignificant lags of the first differences and again ending in the suspected AR(1) model, the estimates of model (3) and the results from its misspecifications tests are:

$$\Delta\hat{P}_{n\text{-}org.t} = \underset{(1.57)}{0.940} - \underset{(-1.52)}{0.101}P_{n\text{-}org.t-1} \qquad \textbf{(3)}$$

LM-test	$F(3,37) = 1.018$ [0.40]
ARCH-test	$F(3,34) = 0.297$ [0.83]
Normal. test	$Chi^2(2) = 3.590$ [0.17]
Hetero test	$F(2,37) = 0.998$ [0.38]
RESET test	$F(1,39) = 0.025$ [0.88]

Model (3) has no misspecifications test rejected and is therefore also accepted as a well specified model. The coefficient used for testing the unit root is a bit smaller (-0.10) and has a larger t-value of -1.52. But once again this t-value is smaller than the critical value for the Dickey-Fuller test with a constant on a 5% level (-2.89). Therefore the null hypothesis of a unit root process in the prices of non-organic eggs cannot be rejected; which again was expected.

Model (4)

Finding a unit root process in the prices of organic as well as and non-organic eggs makes their cointegration relationship possibly, which statistically is tested in the following model. Deleting insignificant lags of first differences the estimates of model (4) and the results from its misspecifications tests are:

$$\Delta\hat{u}_t = \underset{(-1.29)}{-0.122}\hat{e}_{t-1} - \underset{(-2.47)}{0.369}\Delta\hat{e}_{t-2} \qquad \textbf{(4)}$$

LM-test	$F(3,35) = 0.575$ [0.64]
ARCH-test	$F(3,32) = 1.210$ [0.33]
Normal. test	$Chi^2(2) = 0.646$ [0.72]
Hetero test	$F(2,37) = 0.962$ [0.44]
RESET test	$F(1,39) = 0.331$ [0.57]

Again the model seems well specified and is therefore accepted. The coefficient used in testing for the presence of a unit root process (-0.122) seems different from zero, which is in favour of the hypothesised cointegration relationship. But statistically this is not the case. The critical values for the residual-based unit root test with a constant is -3.34 on a 5% level (Ver-

beck, M: 316. 2004), which indeed is smaller than the observed t-value of -1.29. So the non-stationarity of the residuals from model (1) cannot be rejected, and therefore the overall hypothesis of this essay, namely that the prices of organic and non-organic eggs are cointegrated, is rejected.

Model (5) – (6)

But as noted in section 3, even if no-cointegration between the prices of organic and non-organic eggs cannot be rejected, it is still possibly, that they do cointegrate. And this could be the case, if the error correction term looks significant in the error correction model. Deleting insignificant lags of $\Delta P_{org.t}$ and $\Delta P_{n\text{-}org.t}$ the estimates of model (5) and the results from its misspecifications tests are:

$$\Delta \hat{P}_{org.t} = \underset{(0.30)}{0.014} - \underset{(-1.93)}{0.176}\hat{e}_{t-1} + \underset{(6.14)}{0.791}\Delta P_{n\text{-}org.t} \qquad \textbf{(5)}$$

LM-test	$F(3,36) = 1.538$ [0.22]
ARCH-test	$F(3,33) = 0.047$ [0.99]
Normal. test	$Chi^2(2) = 0.121$ [0.94]
Hetero test	$F(4,34) = 4.322$ [0.01]
RESET test	$F(1,38) = 1.525$ [0.23]

Except from the signs of heteroscedasticity the model seems well specified. The heteroscedasticity could be caused by outliers and implies problems for estimation of variances but not for the coefficients, which are in focus here. Therefore model (5) is accepted as well specified. Using the conventional t-values the coefficient of the error correction term (-0.176) is not significant on 5% level, but it is on a 10 % level (6.11%). This suggest a weak sign in favour of the hypothesised cointegration between the prices of organic and non-organic eggs; meaning that if these prices are cointegrated, the price of organic eggs averagely adjust to disequilibriums with about 18% each quarter. But statistically this is weakly validated and relies on the assumption, that the prices of organic and non-organic eggs are cointegrated; which have not been validated statistically. Therefore it does not seem reasonable to conclude, that the prices of organic and non-organic eggs can be represented by such an error correction model.

Deleting insignificant lags of $\Delta P_{n\text{-}org.t}$ and $\Delta P_{org.t}$ the estimates of model (6) and the results from its misspecifications tests are:

$$\Delta\hat{P}_{n\text{-}org.t} = \underset{(0.17)}{0.007} - \underset{(1.43)}{0.111}\hat{e}_{t-1} + \underset{(6.22)}{0.584}\Delta P_{org.t} + \underset{(2.14)}{0.215}\Delta P_{org.t-2} \qquad \mathbf{(6)}$$

LM-test	F(3,33) = 1.817 [0.16]
ARCH-test	F(3,30) = 0.174 [0.91]
Normal. test	$Chi^2(2)$ = 0.791 [0.67]
Hetero test	F(6,29) = 1.127 [0.37]
RESET test	F(1,35) = 0.739 [0.39]

Model (6) seems well specified and is therefore accepted. The coefficient of the error correction term (-0.111) is smaller than the one in model (5) and not even significant on a 10% level. Also it is negative indicating a movement away from the hypothesised equilibrium of the prices of organic and non-organic eggs. So even though model (6) show the expected non-significant error correction term, it do not indicate, that the prices of organic and non-organic eggs are cointegrated.

5. CONCLUSION

Using quarterly prices from the Danish economy the hypothesis of this essay was, that the prices of organic and non-organic eggs are cointegrated, and therefore that organic and non-organic eggs are close substitutes. Based on a visual inspection this hypothesis was doubted, because the price-differences of the eggs seemed to deviate in the period 2000-2004. Though the prices of organic and non-organic eggs visually and statistically was validated as integrated in order one, and thus as being a unit root process, it has not been possible to reject, that they are *not cointegrated*. Even assuming that they were cointegrated, it was not possible to establish a statistically clear error correction model representation of the prices. Based on these results and the fact that R^2 was larger than the DW in a simple OLS estimated relation (model (1)), the conclusion is, that the relationship between the prices of organic and non-organic eggs are spurious; i.e. model (1) is a spurious regression. This means that the hypothesis of this essay is statistically rejected and therefore that organic and non-organic eggs are economically *weak substitutes* on the Danish market.

Of cause this is a conclusion based on the data and models used in the essay. Therefore some critical reflections on these are demanded. Firstly, the models (2) – (4) could have included a

trend; that is, the prices of organic and non-organic eggs could follow a deterministic trend. Actually these kinds of models were estimated, but it did not change the conclusion, and was therefore not included in the essay as a hypothetic alternative.

Then other kinds of models could have been estimated. For instance, instead of averaging the price of conventional and free range eggs (creating a non-organic variable) multivariate models could have been estimated. Also using factor analysis a non-organic factor could have been estimated and used instead of the averaged variable. Furthermore following Ericsson et al. (289. 2002) the error correction model can be interpreted as a test for cointegration and therefore could have been used as a positive alternative to the negative residual-based test of no-cointegration.

Lastly the sample size is only 43 observations and about 12 of these (the period 2000-2004) seems to deviate from the rest; i.e. the period 2000-2004 could dominate in the short-run, but not in the long-run. Quoting Hendry et al. (2. 2000): "The practical problem facing econometricians is (…) to find any relationships that survive long enough to be useful". But then again, the focus of this essay was whether or not organic and non-organic eggs are close substitutes; an issue based on consumer preferences. And such preferences are expected to change over time, and therefore it is not necessarily informative to use too long time periods. Rather monthly or daily data would have been informative, but unfortunately was not found available.

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8. APPENDIX

MODEL 1

```
Modelling Porg by OLS
The estimation sample is: 1999(1) - 2009(3)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
Constant              5.93150     0.8555     6.93  0.0000   0.5397
Pnonorg               1.08310    0.09489     11.4  0.0000   0.7606

sigma                0.530759  RSS              11.5499199
R^2                  0.760637  F(1,41) =     130.3 [0.000]**
log-likelihood       -32.7521  DW                    0.401
no. of observations        43  no. of parameters         2
mean(Porg_kr)         15.6528  var(Porg_kr)        1.12216

AR 1-3 test:      F(3,38)   =   27.758 [0.0000]**
ARCH 1-3 test:    F(3,35)   =   3.4035 [0.0282]*
Normality test:   Chi^2(2)  =   5.1059 [0.0779]
Hetero test:      F(2,38)   =  0.19191 [0.8262]
Hetero-X test:    F(2,38)   =  0.19191 [0.8262]
RESET test:       F(1,40)   =   36.137 [0.0000]**
```

MODEL 2

A)

```
Modelling dPorg by OLS
The estimation sample is: 2000(1) - 2009(3)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
dPorg_1           0.0857698     0.1720    0.499  0.6213   0.0073
dPorg_2           0.129644      0.1840    0.704  0.4860   0.0144
```

dPorg_3	-0.0339833	0.2011	-0.169	0.8668	0.0008
Constant	1.40362	1.233	1.14	0.2628	0.0367
Porg_1	-0.0880295	0.07944	-1.11	0.2756	0.0349

B)

Modelling Porg by OLS
The estimation sample is: 1999(2) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	1.24334	0.9622	1.29	0.2037	0.0401
Porg	-0.0766725	0.06143	-1.25	0.2192	0.0375

sigma	0.422252	RSS	7.13185401
R^2	0.0374911	F(1,40) =	1.558 [0.219]
log-likelihood	-22.3604	DW	1.81
no. of observations	42	no. of parameters	2
when the log-likelihood constant is NOT included:			
AIC	-1.67786	SC	-1.59511
HQ	-1.64753	FPE	0.186787
When the log-likelihood constant is included:			
AIC	1.16002	SC	1.24276
HQ	1.19035	FPE	3.19022
mean(dPorg_kr)	0.045	var(dPorg_kr)	0.17642

AR 1-3 test:	F(3,37)	=	0.22156 [0.8808]
ARCH 1-3 test:	F(3,34)	=	0.38207 [0.7665]
Normality test:	Chi^2(2)	=	6.0701 [0.0481]*
Hetero test:	F(2,37)	=	0.47575 [0.6252]
Hetero-X test:	F(2,37)	=	0.47575 [0.6252]
RESET test:	F(1,39)	=	0.15983 [0.6915]

MODEL 3

A)

Modelling dPnonorg by OLS
The estimation sample is: 2000(1) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
dPnonorg _1	0.168711	0.1614	1.05	0.3033	0.0311
dPnonorg _2	0.273460	0.1633	1.67	0.1033	0.0762
dPnonorg _3	-0.0710546	0.1736	-0.409	0.6849	0.0049
Constant	1.37851	0.7173	1.92	0.0631	0.0980
Pnonorg _1	-0.150133	0.07991	-1.88	0.0689	0.0940

B)

Modelling dPnonorg by OLS
The estimation sample is: 1999(4) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
dPnonorg _2	0.265936	0.1538	1.73	0.0920	0.0748
Constant	1.47720	0.6219	2.38	0.0228	0.1323
Pnonorg _1	-0.159855	0.06892	-2.32	0.0260	0.1269

C)

Modelling dPnonorg by OLS
The estimation sample is: 1999(2) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.940307	0.5980	1.57	0.1237	0.0582
Pnonorg	-0.100801	0.06643	-1.52	0.1370	0.0544

sigma	0.369119	RSS	5.44994627
R^2	0.0544295	F(1,40) =	2.303 [0.137]
log-likelihood	-16.7121	DW	1.61
no. of observations	42	no. of parameters	2
when the log-likelihood constant is NOT included:			
AIC	-1.94683	SC	-1.86408
HQ	-1.91650	FPE	0.142737

```
When the log-likelihood constant is included:
AIC                   0.891051  SC                    0.973797
HQ                    0.921381  FPE                    2.43787
mean(Y)              0.0370952  var(Y)                 0.13723

AR 1-3 test:        F(3,37)   =   1.0178 [0.3958]
ARCH 1-3 test:      F(3,34)   =  0.29657 [0.8276]
Normality test:     Chi^2(2)  =   3.5902 [0.1661]
Hetero test:        F(2,37)   =  0.99766 [0.3784]
Hetero-X test:      F(2,37)   =  0.99766 [0.3784]
RESET test:         F(1,39)   = 0.025259 [0.8745]
```

MODEL 4

A)

```
Modelling dresnotrend by OLS
The estimation sample is: 2000(1) - 2009(3)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
resnotrend_1        -0.170672    0.09971    -1.71  0.0958   0.0772
dresnotrend_1        0.142968     0.1666    0.858  0.3967   0.0206
dresnotrend_2       -0.414636     0.1487    -2.79  0.0085   0.1818
dresnotrend_3        0.126871     0.1559    0.814  0.4212   0.0186

sigma                 0.284644  RSS                 2.83577231
log-likelihood        -4.22428  DW                        1.63
no. of observations         39  no. of parameters            4
When the log-likelihood constant is NOT included:
AIC                   -2.41612  SC                    -2.24550
HQ                    -2.35490  FPE                  0.0893320
When the log-likelihood constant is included:
AIC                   0.421758  SC                    0.592380
HQ                    0.482976  FPE                    1.52574
mean(Y)             -0.0136159  var(Y)                0.106732

AR 1-3 test:        F(3,32)   =   2.4673 [0.0800]
ARCH 1-3 test:      F(3,29)   =   1.2785 [0.3003]
Normality test:     Chi^2(2)  =  0.44697 [0.7997]
Hetero test:        F(8,26)   =  0.71614 [0.6754]
Hetero-X test:      F(14,20)  =  0.68601 [0.7624]
RESET test:         F(1,34)   =  0.22998 [0.6346]
```

B)

```
Modelling dresnotrend by OLS
The estimation sample is: 1999(4) - 2009(3)

                  Coefficient  Std.Error  t-value  t-prob Part.R^2
resnotrend_1        -0.121726    0.09468    -1.29  0.2063   0.0417
dresnotrend_2       -0.368479     0.1492    -2.47  0.0181   0.1383


sigma                 0.297269  RSS                 3.35801642
log-likelihood        -7.20696  DW                        1.69
no. of observations         40  no. of parameters            2
When the log-likelihood constant is NOT included:
AIC                   -2.37753  SC                    -2.29309
HQ                    -2.34700  FPE                  0.0927873
When the log-likelihood constant is included:
AIC                   0.460348  SC                    0.544792
HQ                    0.490880  FPE                    1.58476
mean(Y)             -0.0030115  var(Y)                0.108449

AR 1-3 test:        F(3,35)   =  0.57485 [0.6354]
ARCH 1-3 test:      F(3,32)   =   1.2029 [0.3245]
Normality test:     Chi^2(2)  =  0.64559 [0.7241]
Hetero test:        F(4,33)   =  0.96183 [0.4414]
Hetero-X test:      F(5,32)   =  0.77567 [0.5745]
RESET test:         F(1,37)   =  0.33095 [0.5686]
```

MODEL 5

A)

Modelling dPorg by OLS
The estimation sample is: 2000(1) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	-0.0140035	0.05117	-0.274	0.7862	0.0025
resnotrend_1	-0.160455	0.1057	-1.52	0.1394	0.0714
dPorg _1	0.101113	0.1845	0.548	0.5877	0.0099
dPorg _2	-0.376030	0.1708	-2.20	0.0356	0.1391
dPorg _3	0.132674	0.1894	0.700	0.4890	0.0161
dPnonorg	0.880268	0.1444	6.10	0.0000	0.5533
dPnonorg _1	-0.165863	0.2198	-0.755	0.4563	0.0186
dPnonorg _2	0.452789	0.1865	2.43	0.0214	0.1642
dPnonorg _3	-0.108098	0.1866	-0.579	0.5668	0.0111

B)

Modelling dPorg by OLS
The estimation sample is: 1999(4) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.0129183	0.04837	0.267	0.7910	0.0020
resnotrend_1	-0.111806	0.09562	-1.17	0.2502	0.0376
dPorg_2	-0.370008	0.1676	-2.21	0.0340	0.1222
dPnonorg	0.894906	0.1380	6.49	0.0000	0.5459
dPnonorg_2	0.330579	0.1774	1.86	0.0709	0.0902

C)

Modelling dPorg by OLS
The estimation sample is: 1999(4) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.0141968	0.05000	0.284	0.7781	0.0022
resnotrend_1	-0.162227	0.09481	-1.71	0.0957	0.0752
dPorg _2	-0.157330	0.1269	-1.24	0.2231	0.0409
dPnonorg	0.886659	0.1426	6.22	0.0000	0.5180

D)

Modelling dPorg by OLS
The estimation sample is: 1999(2) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.0144016	0.04771	0.302	0.7644	0.0023
resnotrend_1	-0.176240	0.09138	-1.93	0.0611	0.0871
dPnonorg	0.790938	0.1288	6.14	0.0000	0.4915

```
sigma                  0.307551  RSS              3.68892287
R^2                    0.502146  F(2,39) =     19.67 [0.000]**
log-likelihood         -8.51638  DW                     1.87
no. of observations          42  no. of parameters         3
When the log-likelihood constant is NOT included:
AIC                    -2.28948  SC                 -2.16536
HQ                     -2.24398  FPE                0.101344
When the log-likelihood constant is included:
AIC                    0.548399  SC                 0.672518
HQ                     0.593894  FPE                 1.73090
mean(dPorg_kr)            0.045  var(dPorg_kr)       0.17642

AR 1-3 test:      F(3,36)   =   1.5382 [0.2213]
ARCH 1-3 test:    F(3,33)   = 0.046937 [0.9863]
Normality test:   Chi^2(2)  =  0.12054 [0.9415]
Hetero test:      F(4,34)   =   4.3229 [0.0062]**
Hetero-X test:    F(5,33)   =   5.2451 [0.0012]**
RESET test:       F(1,38)   =   1.5247 [0.2245]
```

MODEL 6

A)

Modelling dPnonorg by OLS
The estimation sample is: 2000(1) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.0279846	0.04299	0.651	0.5200	0.0139
resnotrend_1	0.134297	0.08936	1.50	0.1433	0.0700
dPnonorg_1	0.260534	0.1813	1.44	0.1611	0.0644
dPnonorg_2	-0.279681	0.1647	-1.70	0.0997	0.0877
dPnonorg_3	0.0598297	0.1582	0.378	0.7080	0.0047
dPorg	0.628531	0.1031	6.10	0.0000	0.5533
dPorg_1	-0.141359	0.1545	-0.915	0.3676	0.0271
dPorg_2	0.336905	0.1429	2.36	0.0251	0.1563
dPorg_3	-0.199791	0.1572	-1.27	0.2135	0.0511

B)

Modelling dPnonorg by OLS
The estimation sample is: 1999(4) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.00634898	0.03996	0.159	0.8747	0.0007
resnotrend_1	0.0806446	0.07931	1.02	0.3162	0.0287
dPnonorg_2	-0.220379	0.1490	-1.48	0.1481	0.0588
dPorg	0.609964	0.09404	6.49	0.0000	0.5459
dPorg_2	0.353484	0.1351	2.62	0.0130	0.1636

C)

Modelling dPnonorg by OLS
The estimation sample is: 1999(4) - 2009(3)

	Coefficient	Std.Error	t-value	t-prob	Part.R^2
Constant	0.00674749	0.04061	0.166	0.8690	0.0008
resnotrend_1	0.111032	0.07785	1.43	0.1624	0.0535
dPorg	0.584184	0.09393	6.22	0.0000	0.5180
dPorg_2	0.214881	0.09891	2.17	0.0365	0.1159

```
sigma                 0.250742  RSS               2.26337398
R^2                    0.56251  F(3,36) =     15.43 [0.000]**
log-likelihood        0.682916  DW                       1.6
no. of observations         40  no. of parameters          4
When the log-likelihood constant is NOT included:
AIC                   -2.67202  SC                  -2.50313
HQ                    -2.61096  FPE                0.0691586
When the log-likelihood constant is included:
AIC                   0.165854  SC                  0.334742
HQ                    0.226919  FPE                  1.18119
mean(Y)               0.049175  var(Y)              0.129339

AR 1-3 test:      F(3,33)   =   1.8165 [0.1634]
ARCH 1-3 test:    F(3,30)   =  0.17362 [0.9134]
Normality test:   Chi^2(2)  =  0.79077 [0.6734]
Hetero test:      F(6,29)   =   1.1270 [0.3715]
Hetero-X test:    F(9,26)   =   1.2506 [0.3090]
RESET test:       F(1,35)   =  0.73910 [0.3958]
```